Comments from the author.....

The article entitled "Using Space Photography of the Earth in the Classroom: Drought in Africa" was written for an educators' magazine, not a technical journal. The audience will be elementary and secondary education teachers. The primary objective is to illustrate that Space Shuttle Earth-looking photography is an enriching addition to classroom curriculum. I concentrated on the African drought situation because the media dramatically brought it to life during the coverage of the Ethiopian situation. Photographs of Lake Chad depict the drought. Also, I believe that it is necessary to provide background material to support the use of the photographs in the classroom.

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(NASA-CR-182948) USING SPACE PHOTOGRAPHY OF THE EARTH IN THE CLASSROOM: DROUGHT IN AFRICA (Lockheed Engineering and Management Services Co.) 15 p CSCL 14E

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USING SPACE PHOTOGRAPHY OF THE EARTH IN THE CLASSROOM: DROUGHT IN AFRICA

Pictographs, artifacts, elder-to-younger narrative, art and architecture, and the written word comprise the human historical record. On the other hand, the Earth's physical history is revealed by its geologic strata, fossilized life forms, and surface landforms. People and their environment are now additionally chronicled by video/audio recordings and other remotely sensed data. Remote sensing, defined as acquiring information about an object or phenomena without any physical contact, includes photography. The advent of space photography has heralded a new realm of opportunities for exploring our world.

Imagine the view from the Space Shuttle if YOU were traveling at five miles per second while circling the Earth every ninety minutes. What could you see? Visualize erupting volcanoes, churning hurricanes, snow and glacier-capped mountain ranges, ocean plankton blooms, and sediment-laden rivers. Of course, there are signs of civilization which are reflected in the straight lines of man-made structures, the sharp delineations of land use patterns, and the pollution of the atmosphere and the oceans.

Those of us who are Earthbound may share a limited perspective of this inspiring experience through the photographs taken by those few who lived it.

Beginning with the Mercury program, astronauts in space have been endowing the Earthbound with a pictorial record of our planet. As an intelligent observer, the astronaut photographer is able to identify and appraise phenomena, thus providing photography useful in Earth science and environmental studies. The Apollo 8 astronauts, enroute to the Moon, took the first series of Earth photographs which vividly illustrated the reality: The Earth is a dynamic spaceship isolated in the stark black vacuum of space; sustained by the Sun, it is a self-contained unit with finite resources and interdependent ecosystems.

Apollo missions provided both regional and spherical views depicting the Earth. The Space Shuttle circles the Earth at altitudes, determined by payload and mission activities requirements, that vary from 110 to 300 nautical miles. Hand-held photographs, taken through the flight deck windows, provide a regional view of the Earth's surface.

We have learned a great deal from the acquired photography, but more importantly the photographs have posed questions for which we still seek answers. Spiral eddies, visible when photographed in the Sun's reflection, rotate cyclonically in the Earth's large water bodies. What forces create them? Why do eddies exist one day and not the next? An atmospheric plume is detected on a photograph. Is the plume evidence of a fire or a volcanic eruption? Where is it? If it is a fire, what is the cause? What is burning?

The ideal objectives of education are to provide conceptual frameworks and basic knowledge, to fuel young minds, and to challenge students to question, to seek, and to solve. After all, people are inquisitive creatures. We are motivated to question the unknown and to quest new challenges and horizons. Does space travel and the perspective it provides satisfy this drive?

Socrates believed, simply stated, that human beings must rise above the Earth in order to understand the world in which they live. Sailors scaled the ship's mast to scan the horizon and frontier scouts sought the highest point to survey the land. Today, Space Shuttle Earth-looking photography permits synoptic viewing of the Earth. Scientists have the opportunity to study entire weather systems, then focus on individual cloud dynamics; and to survey complex mountain ranges, then concentrate on specific geologic structures. The photographs taken by astronauts provide vital data in the monitoring and assessment of the physical and environmental state of our "Spaceship Earth." The same photographs are an effective classroom tool for illustrating a variety of Earth science and social studies concepts and for enriching curriculum.

SPACESHIP EARTH: TIPPING THE BALANCE

Why should we be interested in the physical and environmental state of our spaceship? Events or phenomena that take place across the county line, the nation's borders, or the ocean can affect YOU and the quality of

your life. Perturbations in one part of the biosphere can, in fact, influence ecological processes around the world. Environmental systems -- the pond, the valley, the river, the mudflat, the estuary, the ocean -- are inseparably linked in the integrated ecosystem of Earth.

For example, scientists are focusing on the environmental issues developing in Third World countries. This designation is a general term referring to those nations lacking an industrial base and a technologically skilled labor supply. Normally, subsistence agriculture and exportation of raw materials provide the economic foundation. Consequently, the governments of these countries lack the technological expertise, transportation networks, and manufacturing resources to cope with disaster or large-scale environmental changes.

Located primarily between 30 degrees north and 30 degrees south latitude, these countries represent the extremes in annual precipitation and vegetative cover. Forested, tropical regions with warm temperatures and sufficient precipitation characteristically have nutrient-poor soils which prohibit long-term agricultural development. The traditional swidden or slash-and-burn agriculture, practiced for centuries in many of these areas, was adequate for an earlier era, but now, increasing population pressures and agricultural commercialization have forced cultivators to abandon this practice. The demand for arable land has interrupted the fallow field rotation which is a system of cultivation and noncultivation that permits natural rebuilding of soil fertility and soil moisture. In recent years fewer and fewer acres of productive land have been fallowed and the length of fallow time has been shortened. The decreasing soil fertility is evident in reduced crop yields.

The transitional areas within this region, both north and south of the tropics, are subject to extended periods of drought. In Africa these regions have been occupied historically by nomadic herdsmen who adjusted their migrations to the availability of water and pasture. The establishment of political boundaries without regard to tribal territories and centuries-old traditions has limited nomadic movements. Generally the practice has been to graze animals on marginal lands and to cultivate the more favorable areas, but pressure to produce more food due to the recent population increases has resulted in agricultural encroachment on grazing lands. Both of these trends are impacting the environment.

The encroachment of agriculturalists has forced the pastoral nomads to graze their animals on sparsely vegetated, less fertile, submarginal lands and often on less acreage. The effect is overgrazing, which leaves the soil vulnerable to erosion by wind and water. The hooves of the herded animals compact the soil causing it to be less permeable, and thus permitting more and rapid runoff. Subnormal rainfall over two or more growing seasons is disastrous to cultivated and overgrazed marginal lands where the fields become prime candidates for soil erosion and eventual *desertification*, a process of change by which land becomes desert. The fragile ecosystems of the arid and semi-arid lands are vulnerable to the pressures of overuse and drought, and are the most likely to be affected by degradation of the environment. Diminishing biological productivity and loss of fertile topsoil affect the carrying capacity of the land, the crop yields, and human well-being. The negative interaction of man and nature leads the way to desertification in drought-prone regions.

Drought conditions in Africa over the past several years, graphically reported by the media, have indeed been disastrous. Thirty-six African countries received less than adequate rainfall in recent seasons. Following twelve years of subnormal rainfall, an intense drought began in 1980 and continued into early 1985, seriously crippling the economy of the Sahel and intensifying the environmental deterioration of the land. Thousands of people died due to food shortages.

LAKE CHAD: A CLIMATIC INDICATOR

The Sahel (Fig. 2) is a semi-arid transition zone that lies between the arid sands of the Sahara Desert and the tropical forests of Equatorial Africa. Rainfall over this region normally occurs in the summer months as the Intertropical Front develops at the boundary of the hot, dry Saharan air from the north and the cooler, moister, maritime air from the south. During much of the year, evaporation rates are high and exceed rainfall. When the normal air circulation is perturbed, drought often follows.

The Sahelian drought has caused serious environmental degradation and the loss of livelihood and life. Widespread, regular rainfall over much of the Sahel during the 1985 and 1986 wet seasons produced favorable growing conditions and a sufficient agricultural harvest. However, this rainfall does not signify an

end to the drought crisis. Aberrations in the weather/climate systems have a pronounced effect on the delicate ecological balance in this transitional area. Periods of abnormal rainfall will again occur and the Sahelian population must adapt to additional changes caused by the establishment of political boundaries and increasing population pressures.

The severity of the drought situation is depicted in photographs of Lake Chad. Located in the Central Sahel, Lake Chad (Fig. 3) lies in the southwest portion of a large plain, the Chad Basin. Basins of internal drainage such as Chad are sensitive recorders of climatic fluctuations. Lake Chad is a dynamic water body where the norm is variability. In annual, decadal, and longer cycles, the lake changes size, shape, and depth. Paleo-environmental evidence indicates that the lake completely disappeared several times in the past, and at other times rivalled the Caspian Sea in area.

The lake floor is covered by sand dunes which formed approximately 20,000 to 13,000 years ago at the conclusion of the last ice age when regional climatic conditions were much drier. Lacustrine (lake bottom) sediments were transported by the prevailing winds and re-deposited in crescent-shaped sand dunes on the dry lake floor. At this time the Sahara Desert extended some 600 kilometers south of its present margin. Then some 8,000 to 4,000 years ago wetter conditions prevailed and Lake Megachad inundated 320,000 square kilometers of the Chad Basin covering many of the dunes. Ancient shorelines or strandlines, formed during wet periods, are especially evident along the western perimeter of the modern lake.

Lake Chad is actually two well defined basins which are separated by a sand dune formation that extends east-west across the lake. During periods of high water, this barrier dune becomes a series of islands traversing the lake bed. The northern basin, even though it is 1 to 2 meters deeper than the southern basin, is the first part of the lake to dry up. Average annual rainfall across the lake varies from 500 mm on the southern margins to 200 mm on the northern shore of the lake, thereby resulting in less rainfall and runoff to sustain the water level of the northern basin. The barrier dune impedes water flow from the southern basin.

In 1914 the average depth of the water in Lake Chad was only 1 to 2 meters and the greatest depth was approximately 4 meters. Inhabitants of the eastern side of the lake migrated to the western shore in search of potable water and fresh grazing land for their herds. The barrier dune cut the northern part of the lake from the southern portion and decaying fish covered the bottom of the empty northern basin. By 1916 there had been enough rainfall in the drainage basin to restore Lake Chad to the size depicted in the 1966 photograph (Fig. 1).

The Chari River system with headwaters to the south in the more humid Central African Republic supplies nearly ninety percent of the water volume entering the lake. Seasonal runoff from the various ephemeral rivers and streams and local rainfall account for the remaining input. During the recent drought, the waters of the Chari River steadily declined to dangerously low levels, prohibiting the operation of the ferries used to move food aid into Chad. The low water levels in the lake and floating islands of vegetation hampered navigation.

PHOTOGRAPHS OF LAKE CHAD...

Comparison of a 1966 Gemini photograph (Fig. 1) and a 1982 Space Shuttle photograph (Fig. 4) illustrates the effects of the African drought. In sixteen years, the water surface area of Lake Chad had declined from its modern size of 25,000 square kilometers to approximately 2,500 square kilometers. By 1982 the northern basin was totally dry and the southern basin shoreline had receded significantly. The situation seems to be reversing itself as local rains have filled some of the impounded areas among the sand dunes as shown in a January, 1986, view of the southern basin (Fig. 5). Does this indicate that the drought is over? Will the lake again attain its modern historical size?

Classroom topics include:

1) Use photographs of Lake Chad to illustrate the effects of drought.

2) Discuss climatic change using Lake Chad as an example. Short term. Long term.

3) List the reasons why settlements are located where they are. Consider water resources, transportation crossroads, agricultural land,and mineral resources.

4) The Lake Chad area is a population center in the Sahel. Why?

5) What were the effects of the drought on the local population? Relate the situation to the American Dust Bowl.

6) Discuss the land. Sand dune formation. Interior drainage basin. Folk polders.

7) Discuss the impact of the Sahelian drought on the African continent and the world. How did the industrialized world respond to the media coverage of the Ethiopian situation?

8) Lake Chad is a freshwater lake. How is that possible? Consider the geology of the drainage basin and the circulation of the water in the lake. Contrast Lake Chad to the Great Salt Lake of Utah, Lake Megachad, and Lake Bonneville.

Prints, slides, and transparencies of the Space Shuttle Earth-looking photography may be purchased through three agencies. The photography is indexed by mission, roll, and frame numbers.

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BIOGRAPHY: Margaret C. Kinsler is a Senior Scientist with Lockheed Engineering and Management Services Company at NASA's Johnson Space Center. A graduate of the University of Houston with a B. A. in Geography and a Secondary Education Certification, Mrs. Kinsler has taken graduate studies in Environmental Management. Much of her career has been spent as a remote sensing specialist using satellite digital and image data for land use and agricultural applications. Currently she develops training materials and provides preflight training in Earth observations and Earth sciences for the Space Shuttle Astronauts.

CAPTIONS:

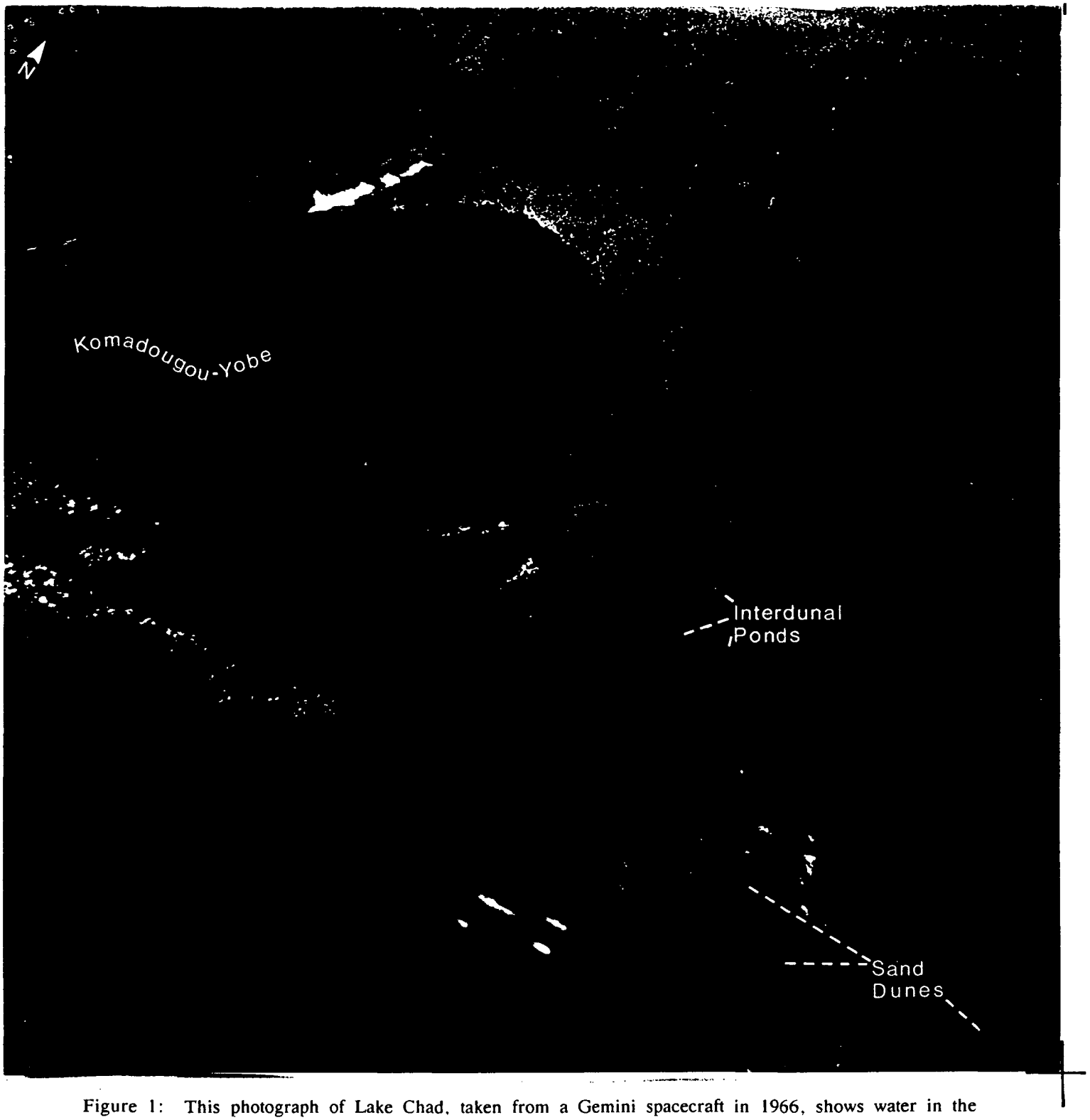
Figure 1: This photograph of Lake Chad, taken from a Gemini spacecraft in 1966, shows water in the northern basin of the lake. During the rainy season, the Komadougou-Yobe River, which drains an arid portion of the basin, usually contains water. However, during the 1980s' drought, the river was completely dry. The Lake Chad area is home for island dwellers who exist mainly by fishing. Inhabitants of the region also practice subsistence agriculture on folk polders--land reclaimed between the dunes--and along the shore and drainage channels. Maize and cereal grains are the primary crops cultivated. Cattle are tended on many of the sand dune islands along the eastern shores of the lake and on the marginal lands in the basin. (Courtesy of NASA, S66-38-444)

Figure 2: The limits of the Sahel, defined by the mean annual rainfall, are illustrated by the shaded area on the map. (From A. T. Grove, illustrated by D. C. Kinsler.)

Figure 3: The drainage catchment of the Lake Chad basin is depicted on the map above. Compare the size of the modern lake to Lake Megachad. The Chari River Delta is a flat, swampy region on the southern margins of the lake. (From A. T. Grove, illustrated by D. C. Kinsler.)

Figure 4: Following the rainy season, Lake Chad, greatly diminished in volume and surface area, was photographed in the sun glint pattern. In this November, 1982, view , the lake bottom interdunal spaces are vegetated by grasses, shrubs, and reeds. Some of the areas are cultivated, but will be abandoned when the soil moisture becomes insufficient. The sunglint pattern is the reflection of the sun's rays off the water's surface directly back to the camera lens. This photographic technique permits the discrimination of water surfaces from land surfaces. (Courtesy of NASA: STS5-39-1022)

Figure 5: Photographed in the sun glint pattern, this January, 1986, view clearly illustrates the water surfaces in the southern basin of Lake Chad. Although the lake does not appear greater in area following a wet season of adequate rainfall, the interdunal areas show evidence of that precipitation. (Courtesy of NASA: 61C-46-026)



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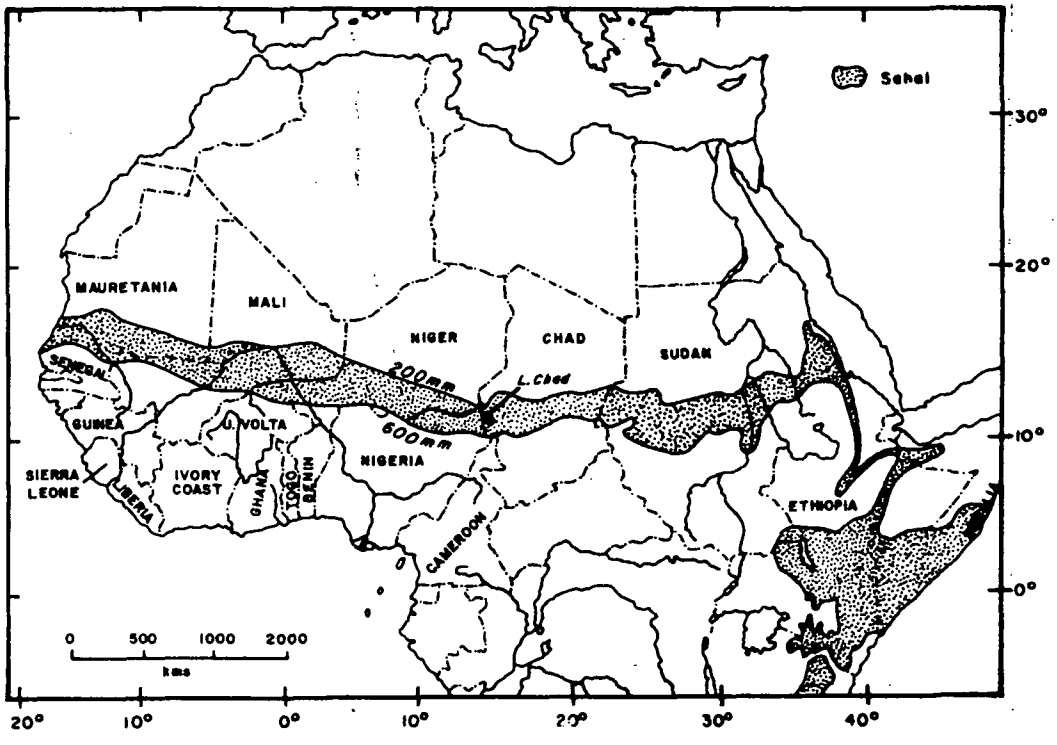

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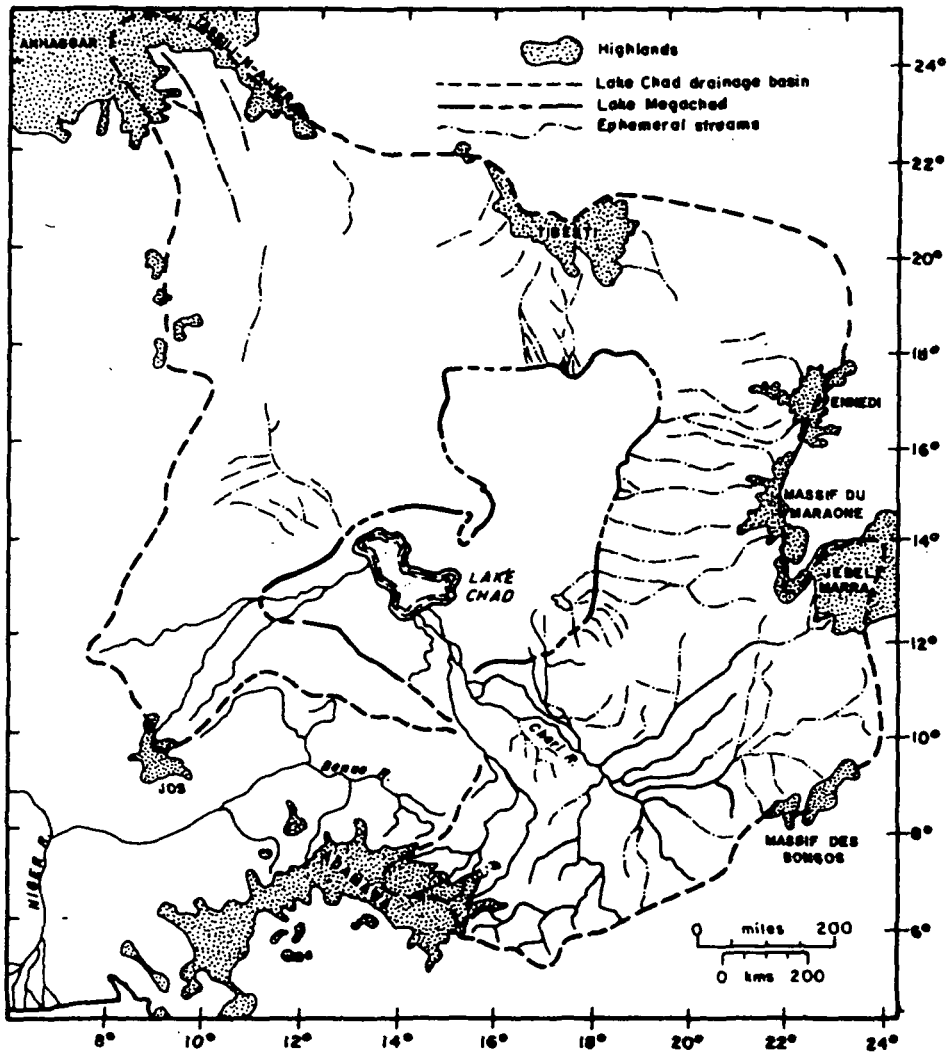

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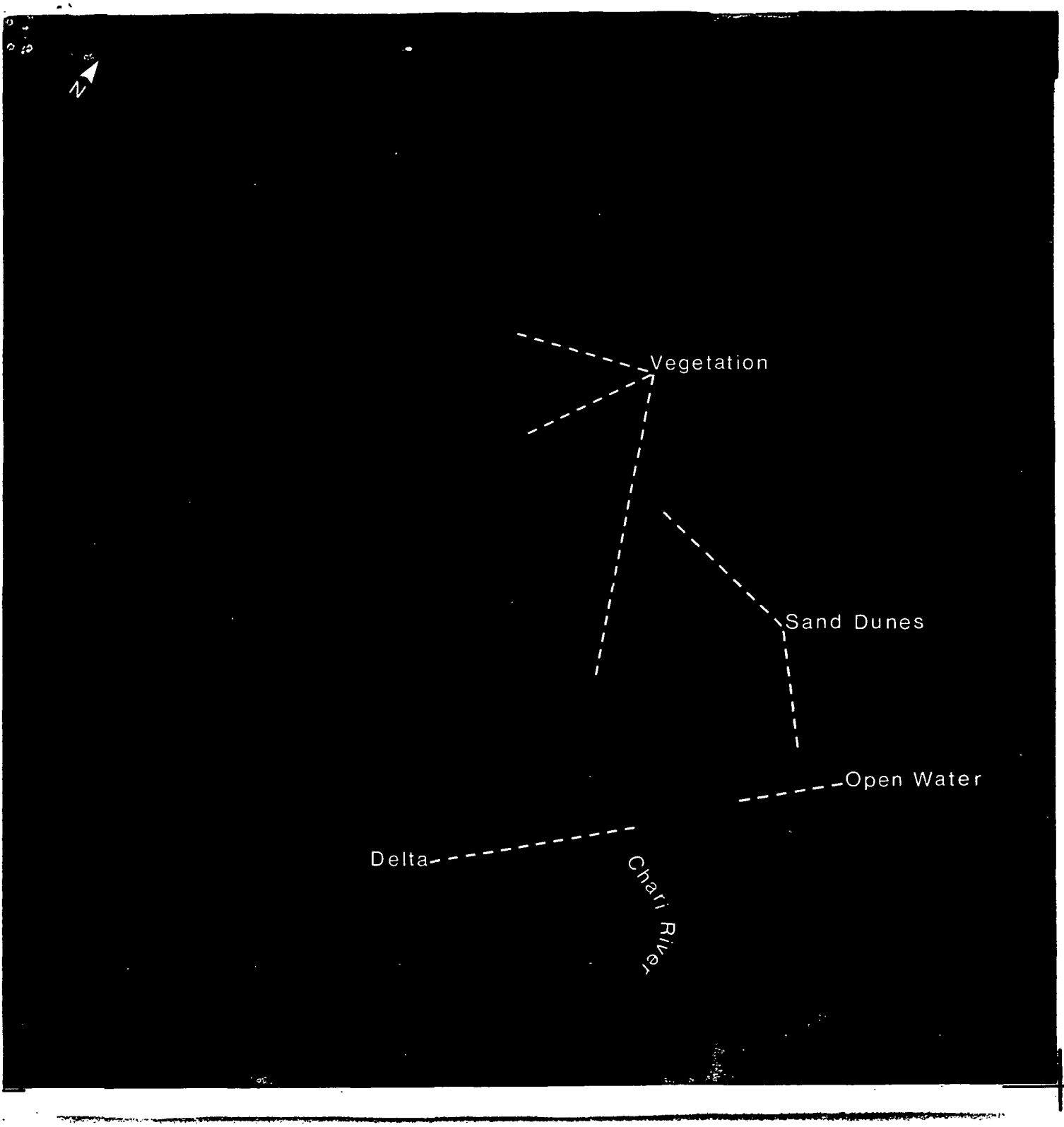

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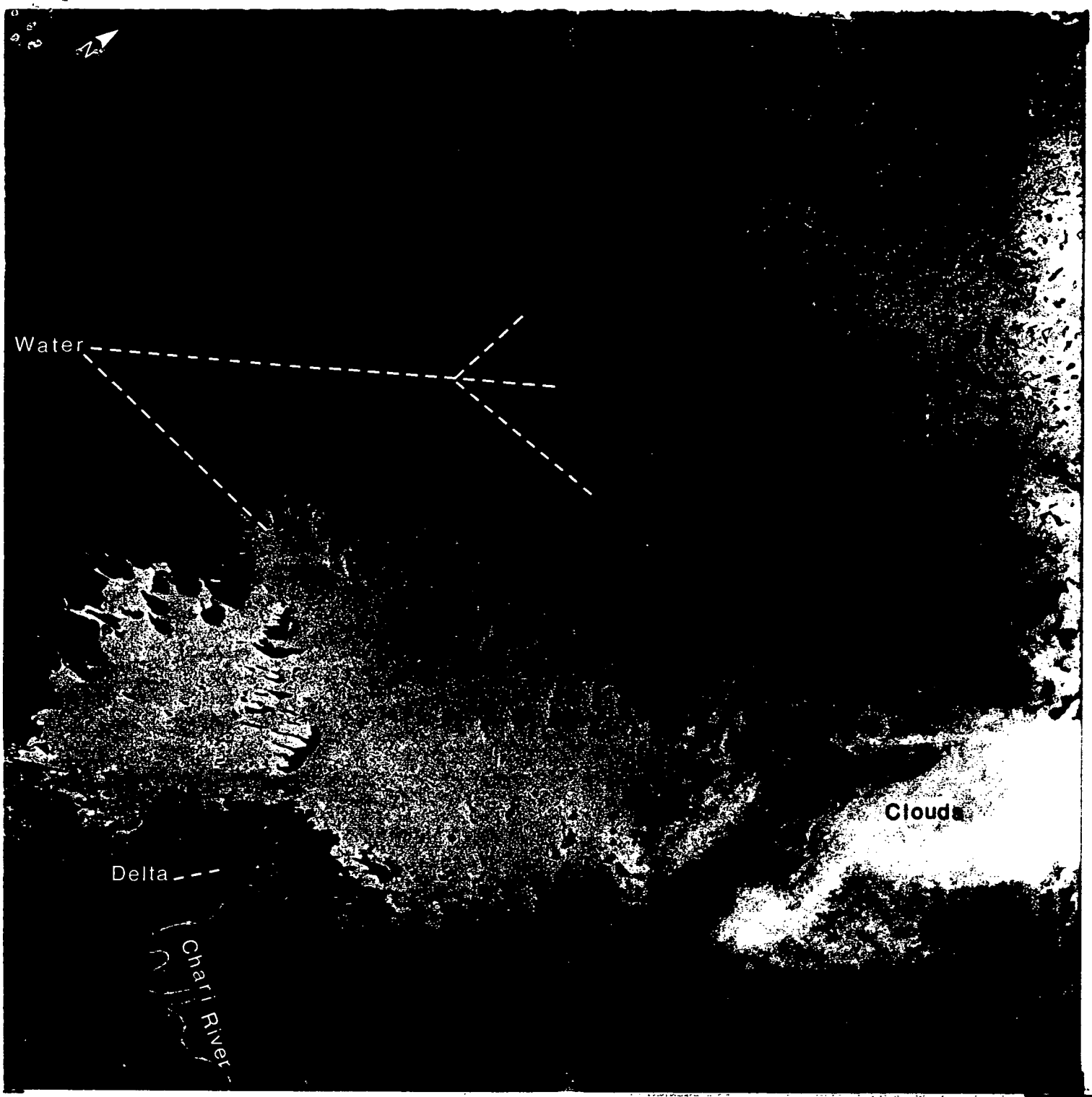

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